

## Detailed Methods for Characterization and Monitoring of Coral Reef Ecosystems and Associated Biological Communities

There are four complementary components to our field methodology. The first is a 25m long belt transect used to quantify fish species' size and abundance. This component is particularly effective for sampling multiple habitat types such as mangroves where the diver is able to swim adjacent to the prop roots, or reefs, where it enables the diver to see what is on the distal side of structures. Additionally, high visibility is not as essential as with the second component, a point-count. The point-count methodology has historically been used in the Virgin Islands and Florida Keys for examination of reef fish communities. In previous missions the point count was added to enable comparison with historical record. Due to personnel limitations the point-count method is only used in the mid-shelf reef habitats in St. John, USVI. Fish data collected from both of these two components is related back to large-scale benthic habitat information to identify spatial patterns in community structure. The third component of the methodology involves taking detailed habitat measurements along the belt transect. These measurements can later be correlated to the fish data in order to gain insight into small-scale fish-habitat relationships. Finally, the fourth component is measuring water quality parameters at each site.

### *I. Belt Transect Fish Census:*

The belt transect diver obtains a random compass heading prior to entering the water and records the compass bearing (0-360°) on the data sheet. This compass heading should allow the diver to stay on the specific habitat type they are intending to census without crossing over into a neighboring habitat. On site, no attempt to avoid structural features within a habitat such as a pile of conch shells, a sand patch or a tire in a seagrass or sand area should be made as these features affect fish communities and are "real" features of the habitats. Visibility at each site must be sufficient to allow for identification of fish at a minimum of 2m away. Once reasonable visibility is ascertained, the diver attaches a tape measure to the substrate and allows it to roll out as progress is made along the chosen compass heading for a distance of 25m. The transect should take 15 minutes regardless of habitat type or number of animals present. This allows more mobile animals the opportunity to swim through the transect, and standardizes the samples collected to allow for comparisons. As the tape rolls out at a relatively constant speed, the diver records all fish species to the lowest taxonomic level possible that come within 2m of either side of the transect. Each survey is 100m<sup>2</sup> in area (25m length X 4m width). To decrease the total time spent writing, four letter codes are used that consist of the first two letters of the genus name followed by the first two letters of the species name. In the rare case that two species have the same four-letter code, letters are added to the species name until a difference occurs. If the fish can only be identified to the family or genus level then this is all that is recorded. If not even the family can be identified then no entry is necessary. The number of individuals per species is tallied in 5cm size class increments up to 35cm using visual estimation of fork length. If an individual is greater than 35cm, then an estimate of the actual fork length is recorded. Although the habitat should not be altered in any manner by lifting or moving structure, the observer should record fish seen in holes, under ledges and in the water column. To identify, enumerate, or locate new individuals a diver may move off the centerline of the transect as long as they stay within the 4m transect width and do not look back along area already covered. The diver is allowed to look forward toward the end of the transect for the distance left along the transect (i.e. if the diver is at meter 15, he can look 10 meters distant, but if he is at meter 23, he can only look 2 meters ahead). In mangrove areas the diver swims close to the prop roots and looks as far into

the mangroves as possible, up to 2m and then out to the edge of the mangrove overhang such that the total area surveyed is still 100m<sup>2</sup>. In this case, some of the survey may necessarily fall on seagrass habitat. This is allowed as the mangrove habitat is defined as a transition zone habitat. As soon as the belt transect diver has passed the 5 m mark, the point-count and habitat divers begin their work

## II. *Point-count Fish Census: Bohnsack-Bannerot (1986)*

The point-count diver records all fish species seen within a vertical cylinder of radius 7.5m that extends from the substrate to the surface of the water. Using a random number of fin kicks and a randomly chosen compass heading the center of the cylinder is positioned to the side or behind the tape rolled out by the belt-transect diver such that there is no overlap between the two surveys. The point-count diver also makes no attempt to avoid features within a habitat (see above). While staying at the center point of the cylinder the point-count diver slowly rotates in a circle. All species seen within the cylinder during a 5 minute period are recorded using the 4 letter codes described above. After the 5 minutes are up, the diver records the number and size (in 5cm size class increments) of individuals seen for each species identified. This is done during one full rotation per species in order from the bottom of the list to the top. Only schools of fishes unlikely to remain in the cylinder past the first 5 minutes are enumerated and measured during the initial time period. In the instance where species observed in the initial period are no longer seen in the area the count and measurement are done by memory. After completion of the point-count survey, the point-count diver and the belt transect diver conduct habitat rugosity measurements (see below).

## III. *Habitat Composition Census:*

The habitat diver follows the belt-transect diver and records data on small-scale benthic habitat composition and structure along the 25-m transect. The habitat diver places a 1 m<sup>2</sup> quadrat divided into 100 (10 x 10cm) smaller squares (1 square = 1 % cover) at 5 separate positions. Each position is randomly chosen before entering the water such that there is one random point within every 5 m interval along the transect. Percent cover is obtained as if looking at the quadrat in a two dimensional plane (i.e. a photograph) vs. three dimensions where percent cover could add up to greater than 100%.

Data are collected on the following:

- 1) *Logistic information* - (diver name, dive buddy, date, time of survey, site code, and meter #'s at which the quadrat is placed).
- 2) *Habitat structure* - to characterize the benthic habitats of the dive site, the habitat diver first categorize the habitat structure of the site (e.g., colonized hardbottom, spur & groove, patch reef, pavement). This is done based on the hierarchical classification used in the benthic habitat maps (Kendall et al. 2001). The habitat diver must identify the broader categories (colonized or uncolonized hardbottom) and, if possible, also identify the more detailed subclasses. The habitat category to which a site is assigned should be made independently of the map so that *in-situ* data can be used for map validation.
- 3) *Abiotic footprint* - defined as the percent cover (to the nearest 1%) of sand, rubble, hard bottom, fine sediments, and other non-living bottom types within a 1 m<sup>2</sup> quadrat. Rubble refers to large or small rocks and coral fragments that are moveable; immovable rocks are considered hard bottom. The percent cover given as a part of the abiotic footprint should

total 100%. In a seagrass area for example, despite the fact that seagrass may provide 50% cover the underlying substrate is 100% sand so this is what is recorded.

To estimate % cover, the habitat diver first positions the quadrat at the chosen meter mark along the transect tape. If the meter mark is an odd number, then the quadrat is placed on left side of the tape; if even, it is placed on the right. Next, the habitat diver lays the quadrat along the substrate (regardless of the slope) and estimates % cover based on a two-dimensional (planar) view (e.g. if bottom is sloping, the quadrat is not held horizontally). Also, the diver should try to use the same planar view for all estimates of % cover.

- 4) *Biotic footprint* - defined as the percent cover (to the nearest 1%) of algae, seagrass, live corals, sponges, gorgonians, and other biota within a 1 m<sup>2</sup> quadrat. The remaining cover is recorded as bare substrate to bring the total to 100%. Again, the diver must use a planar view to estimate % cover of the biota. Seagrasses and gorgonians should not be stacked upright. For example, e.g., if a single seagrass blade crosses 10 squares, then total seagrass coverage should be the sum of the area taken up by that blade in all 10 squares instead of the area covered if the blade was held upright. Species covering less than 0.1% of the area are not recorded. Taxa are identified to the lowest level possible (seagrass-species, algae-genus, sponge-sponge, stony coral-species, and gorgonians-morphological group).

When estimating percent cover, it is important to realize there is a balance between precision and time. For stony corals, the approximate area covered by living coral tissue is recorded. Coral skeleton (without living tissue) is usually categorized as turf algae or uncolonized substrate. Dead coral refers to coral skeleton that has recently lost living tissue because of disease or damage, and has not yet been colonized by turf algae. Turf algae include a mix of short (<1cm high) algae that colonizes dead coral substrate.

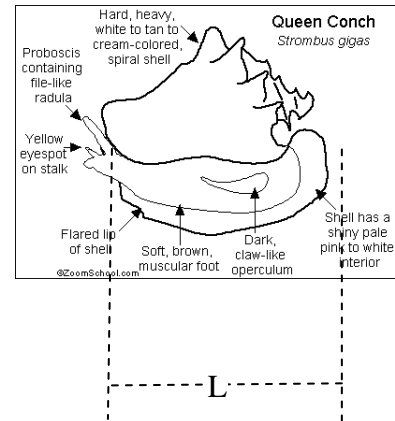
- 5) *Shelter (fish refuge) characteristics* – the number of holes smaller or greater than 15cm in the largest dimension. Hole-width or length is visually estimated. In rubble habitat with many holes (i.e. more than 40), haphazardly sub-sample the quadrat by counting the number of holes in three, 4cm squares (4 % of the quadrat) and then extrapolating to the entire 1m quadrat. Holes do not have to be fully enclosed; rather this is an estimate of places where fish might find refuge, so a ledge can suffice.
- 6) *Transect depth profile* – the depth at each quadrat position. Depth is measured with a digital depth gauge to the nearest 1 ft.
- 7) *Maximum canopy height* – for each biota type, height of both hard (e.g., corals) and soft (e.g., gorgonians, seagrass, algae) structure is recorded to the nearest 10cm.
- 8) *Rugosity* - measured by placing a 6-m chain at two randomly selected positions along the 25-m belt transect. The chain is placed such that it follows the substrate's relief along the centerline of the belt transect. Two divers measure the straight-line horizontal distance covered by the chain (Figure 2). The chain is placed on top of any hard substrate encountered, but not on top of soft corals or sponges since we are measuring hard bottom rugosity. Data on rugosity are collected for reef sites only. Rugosity measurements typically are made by the point-count and belt-transect divers while awaiting the completion of other benthic habitat measurements by the habitat diver.
- 9) *Proximity of structure* – on seagrass and sand sites, the habitat diver records the absence or presence of reef or hard structure within 3m of the belt transect. A score of zero (0) indicates

that no reef or other hard structure is present; one (1) indicates that a reef or hard structure smaller than 4m<sup>2</sup> is present; and (2) indicates that a reef or hard structure larger than 4m<sup>2</sup> is present. The point-count diver also uses this scoring system to record the absence, presence, and proximity of reef or hard structures within their cylinder.

10) *Abundance, size, and lip thickness of queen conchs (Strombus gigas)* – conch encountered within the 25x4m belt transect are enumerated. The size of each conch is determined by measuring the total shell length. Lip thickness will be measured with a plastic caliper to determine maturity.

11) *Abundance of spiny lobsters (Panilaurus argus)* – measured by counting the number of lobsters encountered within the 25x4m belt transect. No measurements are taken.

12) *Photography* – the point count diver will take photos to maintain an anecdotal and permanent visual description of the sites that were sampled.



*Modified habitat composition census for MSR* – The modified habitat survey is done by the point-count diver at deep sites (below 80 ft), where bottom time is limited. The following information is recorded:

1. *Dive logistics* – name of the diver, station ID, date, and the start time of the survey.
2. *Habitat structure* – the dive site is categorized based on the hierarchical classification used to produce the benthic habitat maps.
3. *Depth* – minimum and maximum depth of the survey area, to provide an estimate of bottom slope.
4. *Rugosity (low, medium, or high)* - based on the height of the tallest hardbottom structure.
5. *Abiotic footprint* – an estimate of % cover (within 10%) of hardbottom, sand, and rubble in the 15-m cylinder. The sum of % cover in the abiotic footprint must total 100%.
6. *Biotic footprint* – an estimate of the % cover (within 10%) and min/max height (within 10cm) of live coral, gorgonians, sponges, macro algae, and uncolonized substrate in the 15-m cylinder. The sum of % cover (including uncolonized substrate) in the biotic footprint must total 100%.

#### IV. *Water quality measurements*

Measurements of water quality parameters at each site are taken with a HydroLab at 1 meter below the water's surface and at the bottom. The following parameters are measured: temperature, conductivity, turbidity, and chlorophyll content.